PATENT SPECIFICATION

DRAWINGS ATTACHED

1,073,503

1,073,503

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Int. Cl.: H 01 s 3/08 //G 02 b

Optical presetting means for laser applications.

COMPLETE SPECIFICATION

We, CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE, a body corporate organised and existing under the laws of France, of 15 Quai Anatole France, Paris, Seine, France, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to optical presetting means for the application of a laser beam.

In many applications of lasers, use of a laser beam involves an immediate destruction or alteration of the workpiece at the point or zone where the beam impinges. It is therefore not practical to control the positioning of the laser beam by direct observation because if the beam initially strikes the workpiece at the wrong place, an undesired and irreversible change may be made in the workpiece before the position or direction of the laser beam can be adjusted. For example in micro welding or micro boring the welding or boring work is carried out by the laser beam at its point of impact as soon as it emitted, whereas it would often be desirable to position the point of impact first; to take another example, applications of the laser to medicine, surgery or biology require that before there is any emission of the laser beam its future point of impact should be positioned with great accuracy. Moreover it is often necessary, both in micro welding and micro boring and in medicine or biology, foi the future point of impact of the laser beam to be positioned at a specific shallow depth above or below the surface of the object treated, that is to say, at a predetermined position.

The subject matter of the invention is optical presetting means which satisfy these needs and which do so with the usual advantages and in particular with the accuracy of optical processes.

To be more specific, the invention relates to a device which makes it possible to mark out optically and without any emission of the laser beam both the axis which this beam will follow and the point where it will converge.

According to the invention, we provide optical presetting means for the application of a laser beam, comprising a system capable of producing a laser beam and at least two units each capable of projecting a light beam, each of the two units being mechanically associated with the laser system, and located so that the two light beams intersect at the focal point of the laser beam or at a predetermined position in relation thereto.

The member emitting the laser beam may be the outlet face of a laser head, or the outlet of its optical system, or the outlet of an optical transmission path associated with a laser head, such a path may for example comprise a flexible light conductor. Similarly, the light-projecting units may also comprise flexible light conductors.

Preferably but not necessarily, the various light beams are individualised visually, for example by their colours and/or shapes; this arrangement facilitates adjustment and has further advantages which will be mentioned later.

The invention may be applied equally well to apparatus which is stationary, being heavy and bulky, and to manual apparatus which must be lighter.

The invention will be described by reference to Figs. 1 to 14 of the accompanying drawings, which are given as non-restrictive examples and in which:

Fig. 1 is a diagrammatic elevation of an embodiment of the invention with an integral laser head and two integral light projectors,

Fig. 2 is a diagrammatic section through a parallel light projector suitable for the Fig. 1 embodiment,

Fig. 3 is a diagrammatic section through a convergent light projector suitable for the

Fig. 1 embodiment,

Fig. 4 includes three views of the image formed by the laser beam in planes PP, CC and LL in Fig. 1,

Fig. 5 includes three views of coloured images formed by two light projectors in the planes PP, CC and LL in Fig. 1,

Fig. 6 is similar to Fig. 5 but relates to shaped light beams,

Fig. 7 is similar to Fig. 1 but with the optical means of the laser head mounted in a telescopic tube,

Fig. 8 is similar to Fig. 1, but the optical means of the laser head comprises two mirrors, one spherical and the other parabolic,

Fig. 9 is similar to Fig. 1 but with three projectors,

Fig. 10 is similar to Fig. 5 but is for the three projectors in Fig. 9,

Fig. 11 is an elevation of an embodiment of the invention with a separate laser head and three light projectors,

Fig. 12 is an elevation similar to Fig. 11 but with the laser head transferred to the stand, and

Figs. 13 and 14 are two diagrammatic views of two guns according to further embodiments of the invention.

Referring to the diagrammatic elevation in Fig. 1, this shows an embodiment of the invention with an integral laser head and two integral light projectors, which are also termed light-projecting units in this specification. A double bracket 1 holds the laser head 2 at its centre and a light projector 3 and 4 at each end, each projector having a lamp 5 and 6 with a coloured filter or diaphragm 7 and 8 emitting a light beam 9 and 10; the laser head 2 is equipped with optical means 11 which focuses the laser beam 12 at the point 13 in the focal plane 14 of the means 11; the bracket and the projectors are adjusted so that each light beam 9 and 10 passes through the focus 13 of the laser beam 12.

The light projectors 3 and 4 may be of any known type. In particular they may, as shown in Fig. 1, be of a type which emits a substantially parallel light beam 9-10; a projector of this type may be of very simple construction, as shown in Fig 2, and comprise a light source 5-6 placed substantially at the focus of a convergent lens 15; the coloured filter or diaphragm 7-8 is located beyond the lens 15. The light projectors may equally well be of the type emitting a convergent light beam; as shown in Fig. 3, such a projector may comprise a light source 6-5, a condenser 16 and an objective 17 emitting a light beam 18 which converges at a point 19 coinciding with the focus 13 of the laser beam 12 or located in a given manner in relation to the focus 13 as will be described hereinafter.

It is known that, chiefly because of the spherical aberrations of the optical means 11, the laser beam 12 produces a point image 13 only in the plane 14 as shown in Fig. 4 (in the centre at *p*; which is a plan view along the line PP in Fig. 1; if the plane 14 is a little too close, for example along the line CC in Fig. 1, the laser beam 12 produces as an image (Fig. 4 at *c*) a disc surrounded with a brighter annular zone; if on the other hand the plane 14 is a little too far away, for example along the line LL in Fig. 1, the laser beam produces as an image (Fig. 4 at *l*) a disc with a brighter circular zone in the centre.

It has already been mentioned that the light beams according to the invention are preferably individually identifiable visually. For example, the beams 9 and 10, if of parallel light and circular cross section may be respectively blue and red, this being done by means of coloured filters located at 7 and 8. Under these conditions the focal plane 14 will be made to coincide with the focus 13 of the laser beam 12 in the absence of the laser beam if the image produced by the beams 9 and 10 is an elliptical spot (blue+red) as shown at *p* in Fig. 5, which is a plan view along the line P-P in Fig. 1; the position C-C of the object plane 14 will be obtained if two elliptical spots are observed, a blue one on the left and a red one on the right as shown at *c* in Fig. 5; the position L-L of the object plane 14 will be obtained if two elliptical spots are observed, a red one on the left and a blue one on the right as shown at *l* in Fig. 5.

It will be noted that the two coloured beams make it possible for the position of the laser beam in relation to an object to be worked upon to be adjusted before there is any emission of the laser beam; this possibility of adjusting the direction is sufficiently clear per se, but the possibilities of adjusting the distance should be explained. Firstly, observation of an elliptical spot (blue+red) ensures exact focusing of the future laser beam; secondly, observation of two elliptical spots, one blue and one red, indicates that there is a spacing between the plane eventually to be occupied by the surface of the workpiece to be worked on and the focusing plane of the future laser beam; but in addition the relative position of the two spots, for example the blue one on the left and the red one in the example in question, indicates the direction of the spacing (in this case the laser head and the said plane are too close), and the relative distance of the two spots (and of their common portion if any) indicates un-ambiguously, accurately and faithfully the size of the distance between the said plane and the focusing plane of the future laser beam. These advantages are important in themselves; they also bring the

important advantage that, for example if it is necessary to position the focal point of the laser beam at a given depth below the said plane, it will be sufficient to observe a light image as at *c* in Fig. 5 in order to be sure that the future laser beam will be focused at a corresponding depth below the said plane. More specifically, it is sufficient to calibrate the apparatus by calculation and/or observation in order to make each value of the spacing between the said plane and the focal plane of the laser beam correspond to a particular pattern formed by the two coloured spots making it up, and in order to be sure of obtaining the desired focusing of the future laser beam it is sufficient to set the apparatus to obtain the particular pattern in question. This embodiment of the invention has the further advantage that the setting with two coloured spots can be carried out whatever the ambient lighting may be; this is of prime importance in an operating theatre glaringly lit by a scialytic device, the characteristic of which is to eliminate shadow.

In a case where the light beams 9 and 10 are convergent (for example as in Fig. 3) instead of being of substantially parallel light rays, the same advantages will obviously still be obtained; moreover, when the point of convergence 19 of the beams 18 is in the plane 14 a very clear and very luminous point is obtained (instead of the elliptical spot *p* in Fig. 5), thus making adjustment still more accurate.

Fig. 6 is similar to Fig. 5 but corresponds to the case where the two light beams are in accordance with this embodiment of the invention, individualised by shaping. The projectors 3 and 4 of Fig. 1 have diaphragms at 7 and 8, for example of triangular outline. The two beams 9 and 10 then produce in the plane CC two separate triangular images with the two opposed apexes opposite one another, in the plane PP two triangular images exactly joined, one apex of one coinciding with the opposed apex of the other, and in the plane LL two more or less superposed triangular images. This clearly produces the advantages already mentioned in connection with the coloured beams. Fig. 6 represents two beams of substantially parallel light rays, but the two beams, which are individualised by shaping, may equally well be convergent as already mentioned. The beams of parallel or convergent light may of course be coloured as well as being shaped.

Fig. 7 is similar to Fig. 1, like members bearing like references. In Fig. 7 the optical means 11 of the laser head 2, which has a short focal distance, is mounted in a telescopic tube 21, the other arrangements and the advantages obtained are the same as already described.

Fig. 8 represents different optical means for the laser head 2. The laser beam is received by a small spherical convex mirror 25 and picked up by a concave parabolic mirror 26.

Fig. 9 is similar to Fig. 1, but the bracket 1 is a triple one and holds three light projectors 31, 32 and 33, each with a lamp 34, 35, 36 emitting a light beam 37, 38, 39. The various patterns formed by the three light beams are shown in Fig. 10, which is similar to Fig. 5. It will be noted that in the focal plane P or p of the laser beam the pattern results from superposing three ellipses differing only in the directions of their major axes, but that outside this plane the pattern is a Y-shaped one, the direction of the Y by itself indicating whether the plane upon which such a pattern is produced is above or below the focal plane of the laser beam.

Fig. 11 shows an installation including a triple bracket 1, holding three light projectors 31, 32, 33 and the optical means 11 of the laser, also the three light beams 37, 38, 39 and the laser beam 12, applied to a patient on an operating table. The triple bracket 1 is held by an arm 41 having a knee-joint 42 carried by the arm 43 of the stand 44, and the movements of the triple bracket 1 are controlled manually by a lever 45 with a manipulating knob 46. The laser head 2 is connected to the optical means 11 by a flexible light conductor 47, for example made of fibreglass, and the three light projectors 31, 32, 33 are also connected by flexible light conductors 48, 49, 50 to a source of light 51 with a lamp 52. The laser head 2 and the light source 51 are carried by an arm 53, which may be integral with or rigidly connected to the arm 41 or the arm 43 as desired or convenient.

Fig. 12 shows a further installation. It contains the same chief elements with the same references as Fig. 11. The flexible light conductors 47, 48, 49, 50 are shown equipped with flexible metal sheathing. The laser head 2 is located in the base of the stand 44, as is the apparatus for supplying and controlling the laser; the laser beam leaving the head 2 rises within the stand 44, is reflected by a flat mirror 61 at 45° to its original direction into the arm 43, and by another mirror 62, placed in the joint 42, into the flexible light conductor 47. Instead of mirrors as shown, any other optically equivalent device may of course be used, for example totally reflecting prisms. The patterns produced by the light beams on the patient may be observed at a distance by means of a television camera 63 mounted on the stand 44 and connected by leads 64 to one or more receivers, one, 65, being shown. The stand 44 may be equipped with a retractable mirror 66 which, in its operating position, reflects the laser beam 12 into a flexible lead 67: this provides a supply of laser beam avail-

able, for example, for the manual apparatus which will now be described.

It has already been mentioned that the invention also applies to manual apparatus or guns which of course make use of the devices described above. Fig. 13 shows an example of a gun 70 with a grip 71 and a trigger 72, comprising the laser head 2 with its optical means 11 and two light projectors 3 and 4 to which light is supplied by two flexible light conductors 48 and 49. Another gun shown in Fig. 14 comprises two light projectors 3 and 4 each comprising a lamp 5 and 6 and two flat mirrors 81, 82, 83, 84. A flexible light conductor 73 supplies the laser beam, which is focused at 13 by the central part of a lens 85, the edges of which make the pencils of light reflected by the flat mirrors 83 and 84 converge on a plane 14. The gun may be supplied with laser beam by the stationary installation shown in Fig. 12; in this case the flexible light conductors 67 (in Fig. 12) and 73 (in Fig. 14) are optically linked or merged.

WHAT WE CLAIM IS :—

1. Optical presetting means for the application of a laser beam, comprising a system capable of producing a focussed laser beam and at least two units each capable of projecting a light beam, each of the two units being mechanically associated with the laser system, and located so that the two light beams intersect either at the focal point of the laser beam or at a predetermined position in relation thereto.

2. Means according to claim 1, wherein the mechanical association is made between the outlet of a laser head and the light-projecting units.

3. Means according to claim 1, wherein the mechanical association is made between the outlet of the optical system of a laser head and the light-projecting units.

4. Means according to claim 1, wherein the mechanical association is made between the outlet of an optical transmission path associated with a laser head and the light-projecting units.

5. Means according to claim 1, wherein said mechanical association is made between the outlet of a laser head on the one hand and the outlets of associated optical transmission means, for example comprising flexible light conductors, on the other hand.

6. Means according to any of the preceding claims, wherein the various light beams are individually identifiable visually, for example by their colours.

7. Means according to claim 6, wherein the various light beams are individually identifiable visually by their cross-sectional shapes.

8. Means according to any of the preceding claims, wherein each of the said light beams is made up of parallel rays.

9. Means according to any of claims 1-8, wherein the various light beams are point convergent at the focal point of the laser beam.

10. Means according to claim 4 in which the said optical transmission path comprises a flexible light conductor.

11. Optical presetting means for the application of a laser beam and including a device capable of producing a laser beam substantially as herein described with reference to and as illustrated in any one or more of the accompanying drawings.

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SHEET 1

FIG. 1

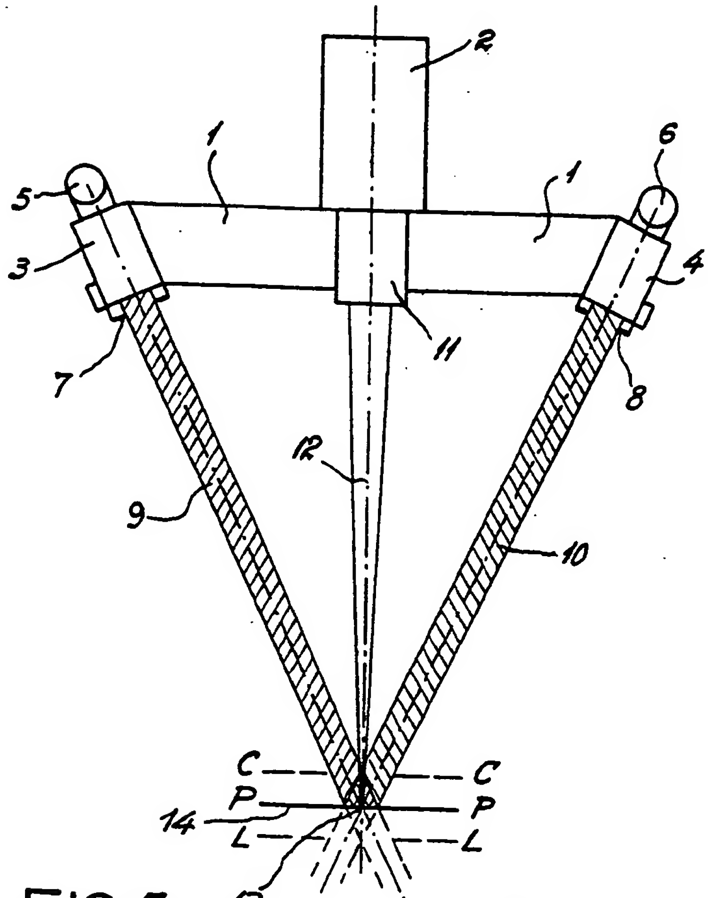


FIG. 5

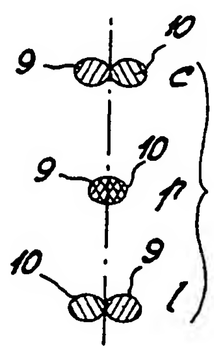


FIG. 4

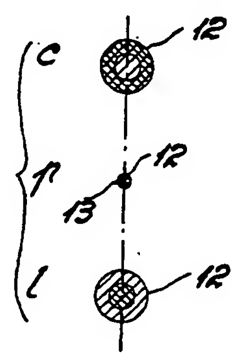


FIG.2

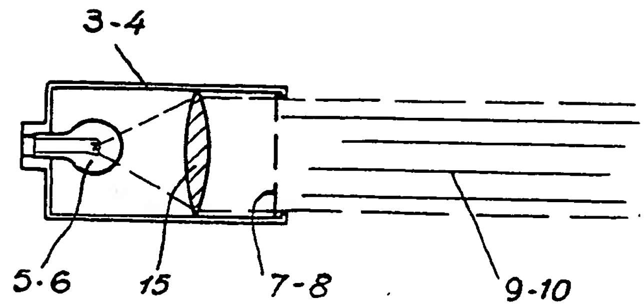


FIG.3

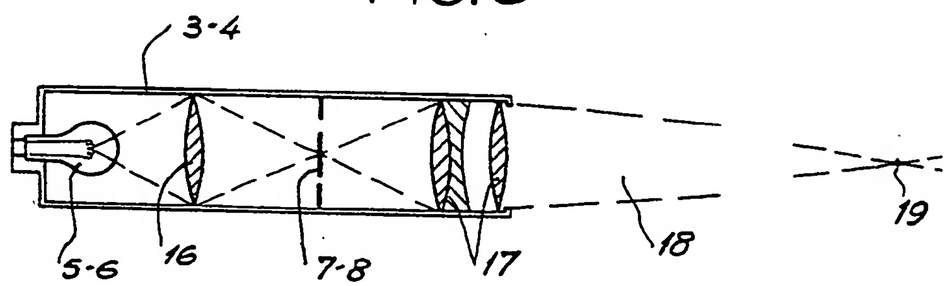
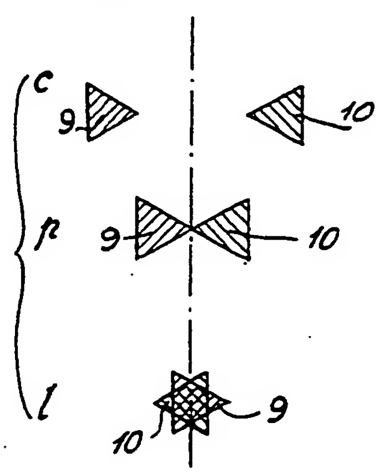


FIG.6



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SHEETS 2 & 3

FIG.7

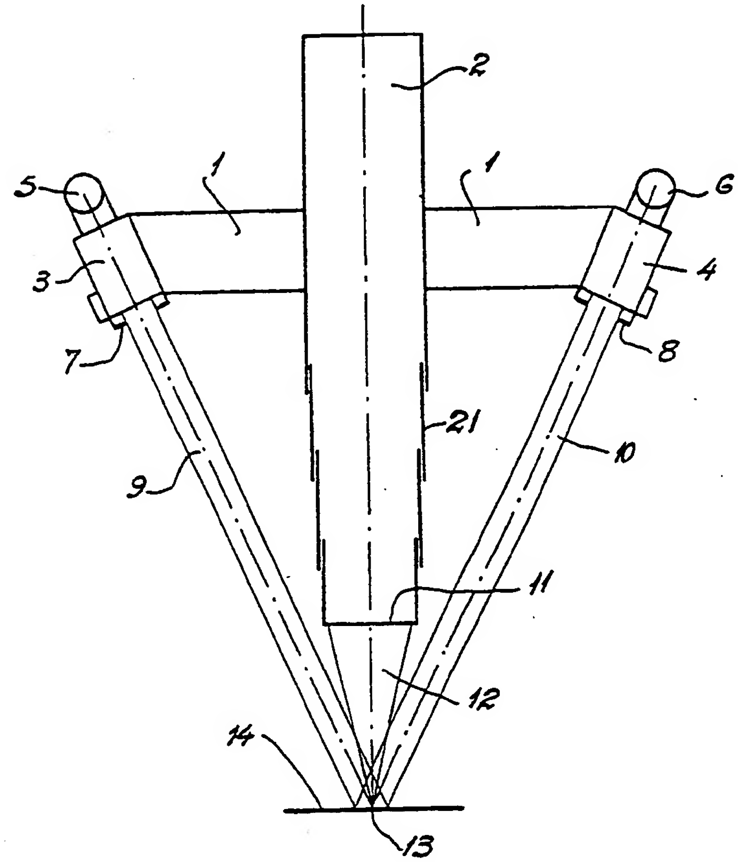

FIG.8

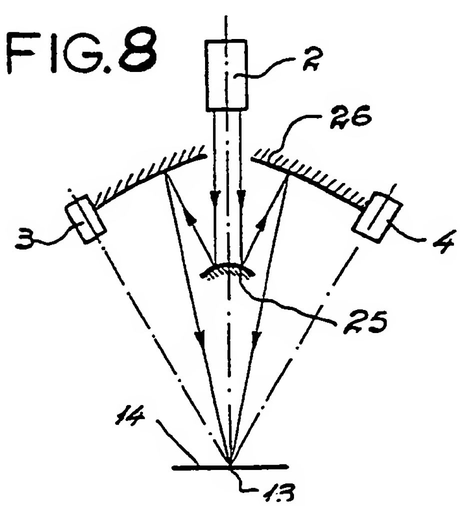

FIG.2

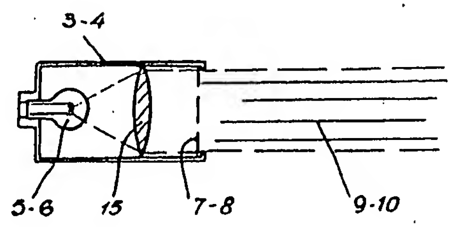

FIG.3

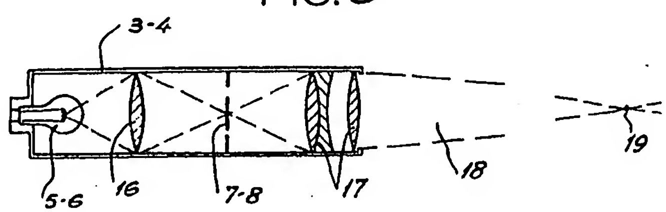

FIG.6

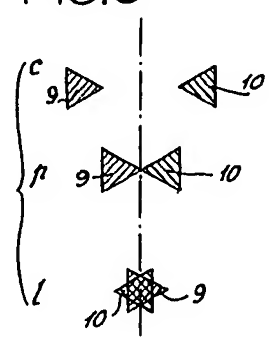

FIG.7

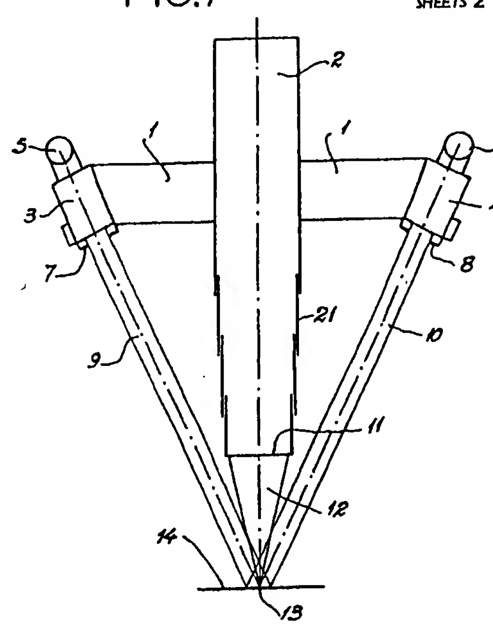

FIG.8

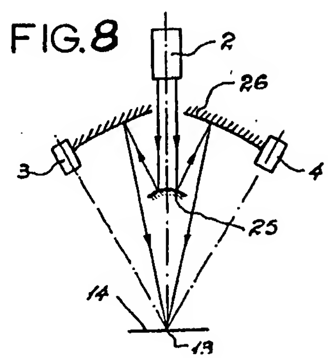

FIG. 9

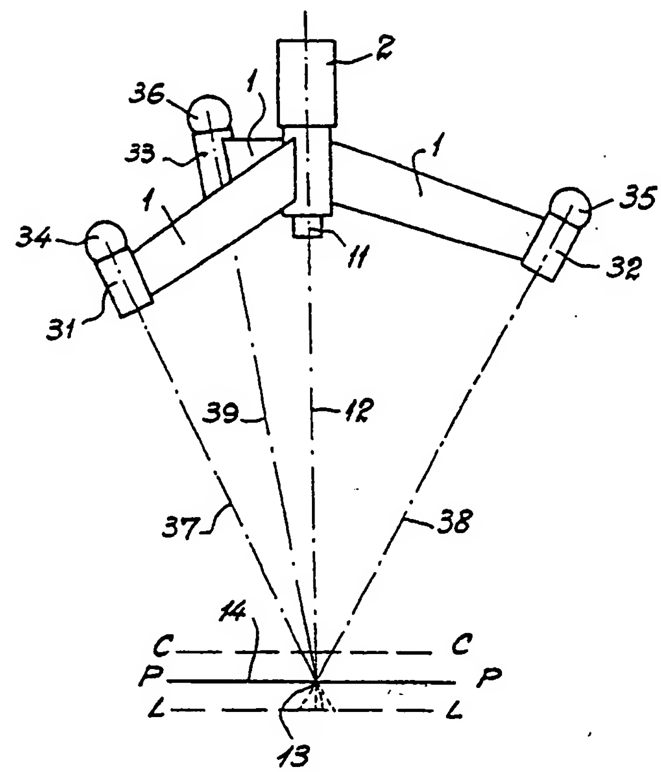
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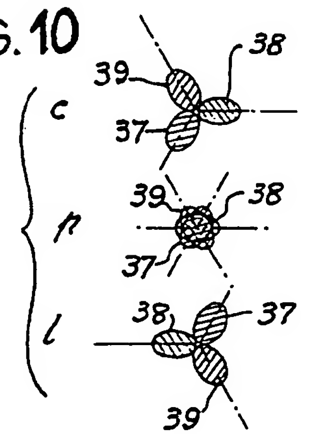
FIG. 10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SHEETS 4 & 5

FIG. 11

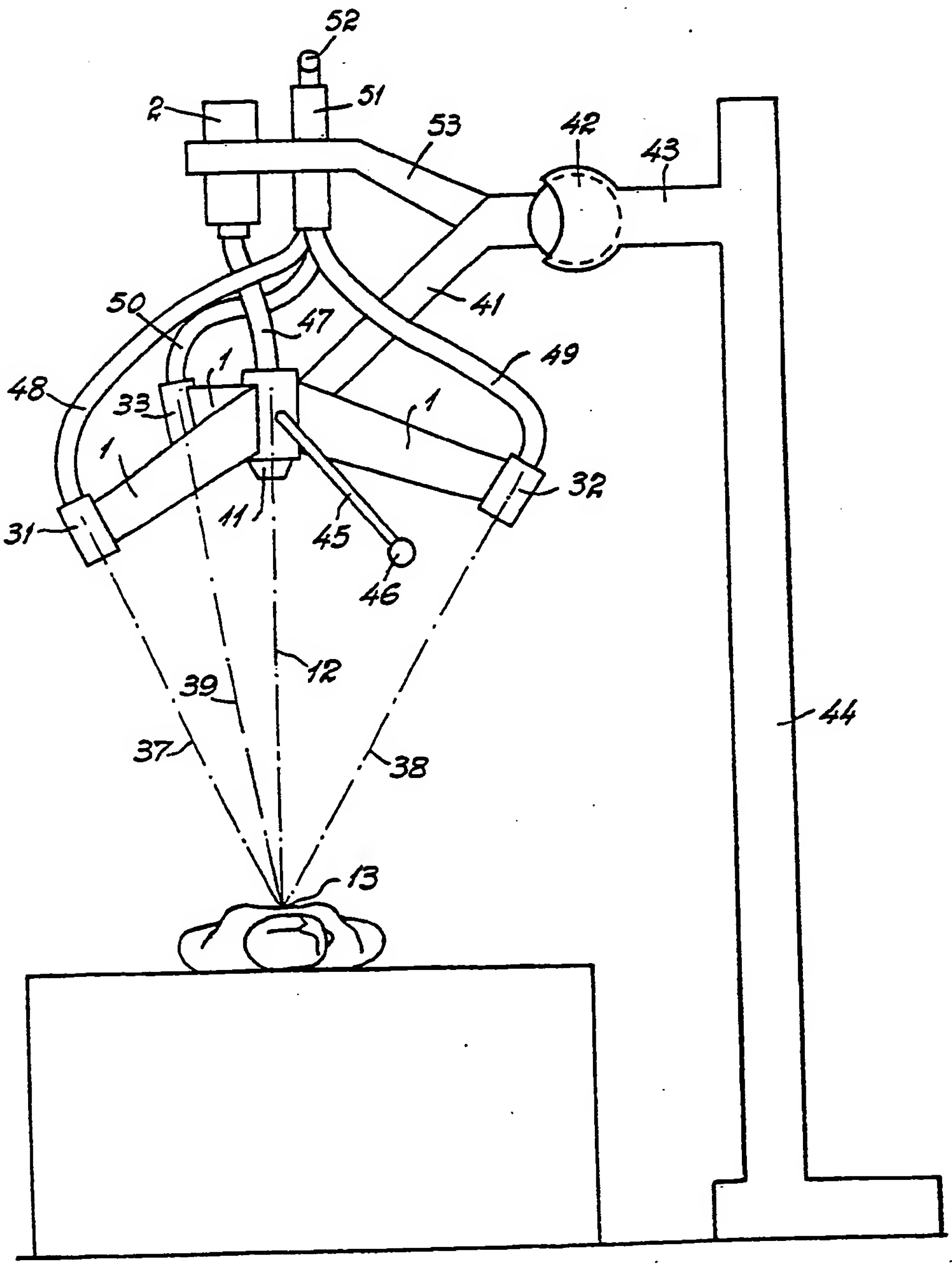


FIG. 9

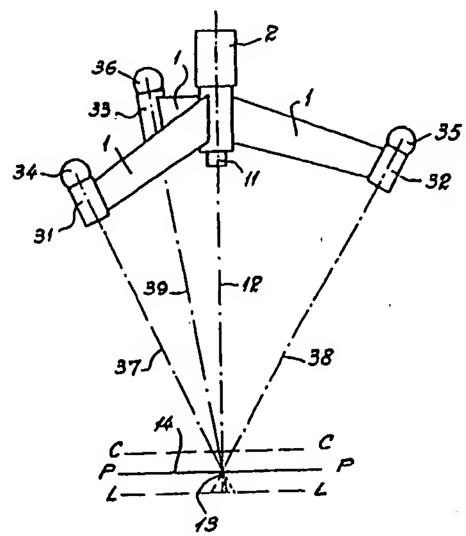


FIG. 10

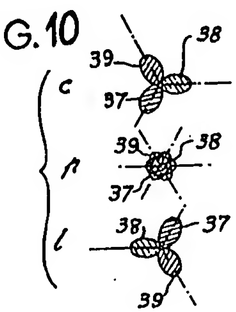


FIG. 11

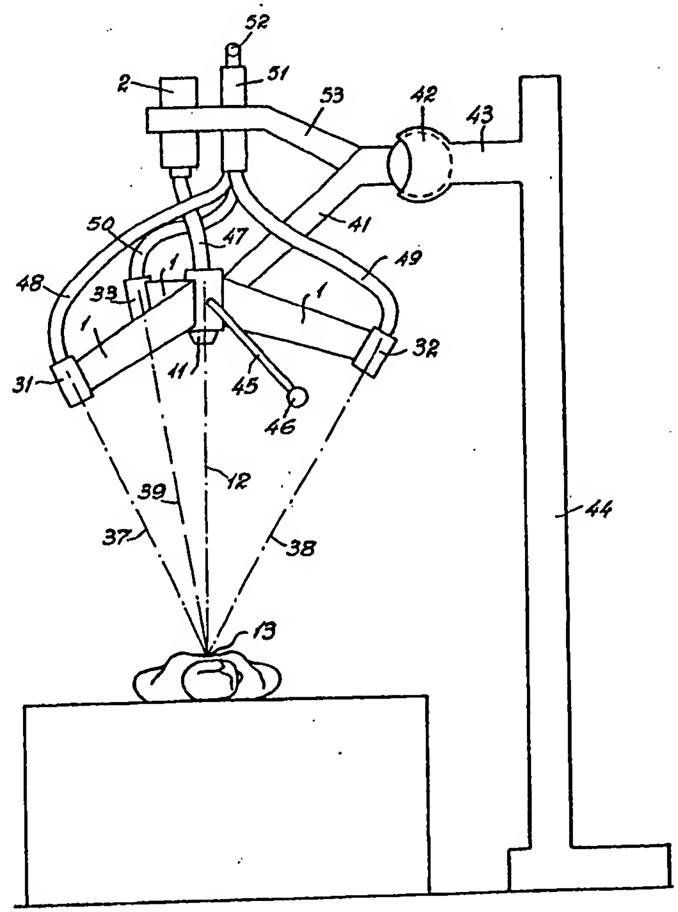
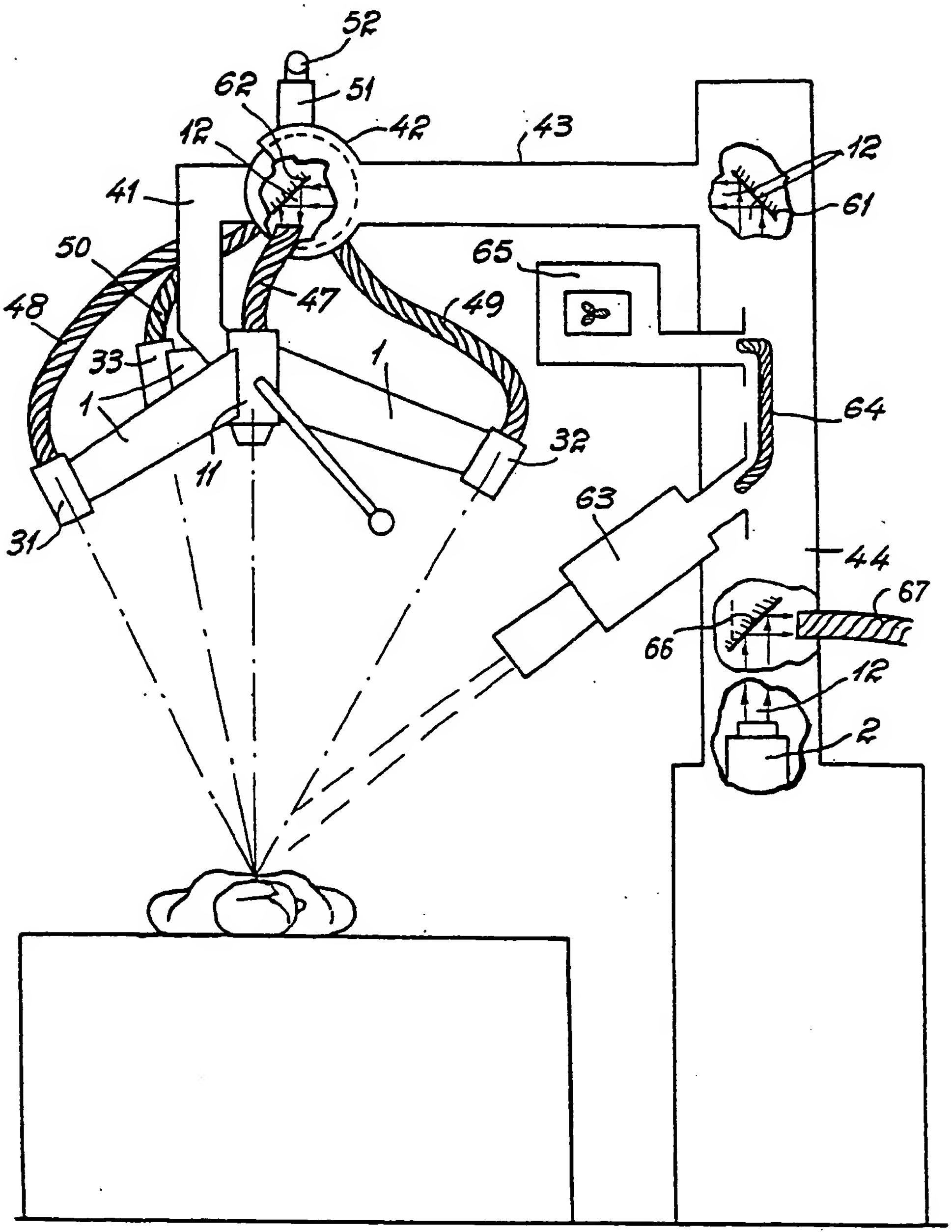


FIG.12



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SHEETS 6 & 7

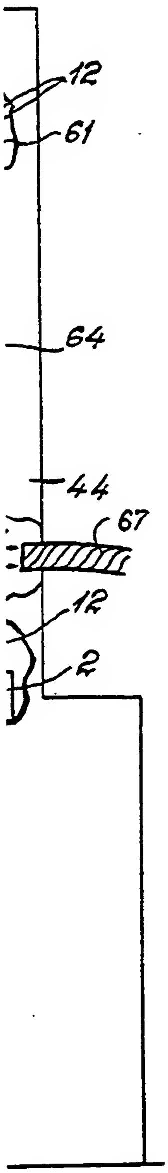


FIG. 13

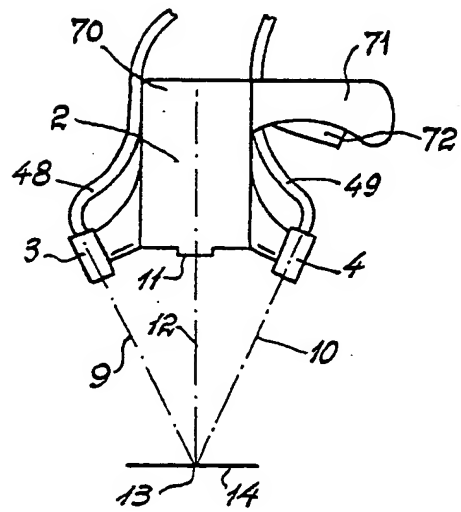
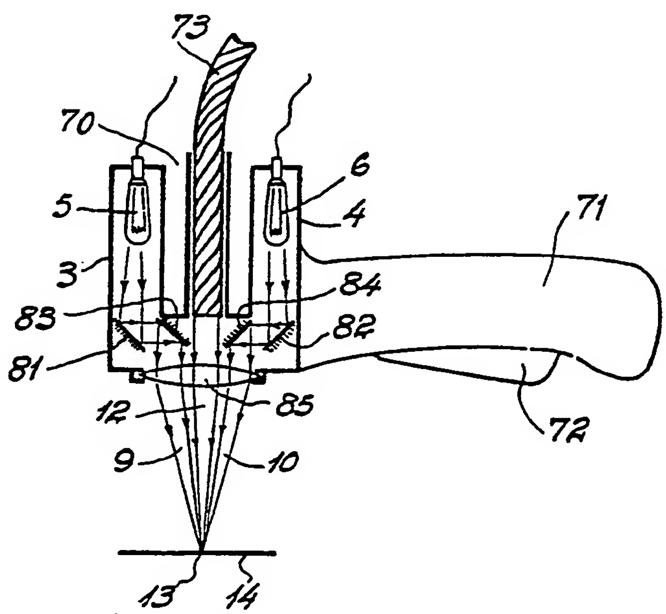


FIG. 14



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SHEETS 6 & 7

FIG.12

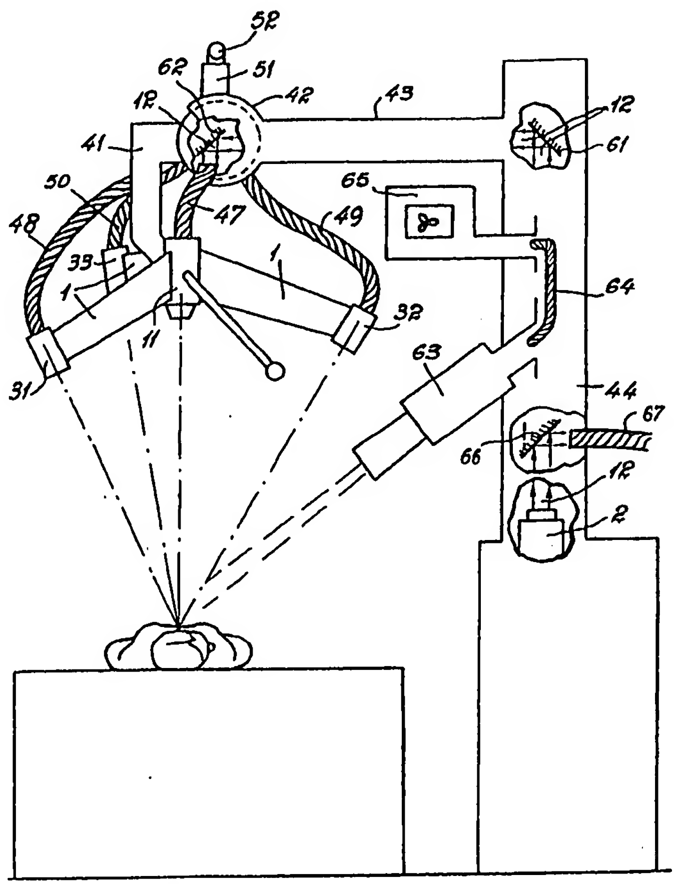

FIG.13

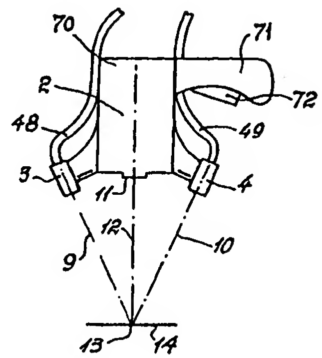

FIG.14